Percolation Model of the Stochastic Effect of EUV Resists

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Summary

• Properties of exposure and development of EUV resists based on metal nanoparticles are investigated using a simple, general method of statistical mechanics.

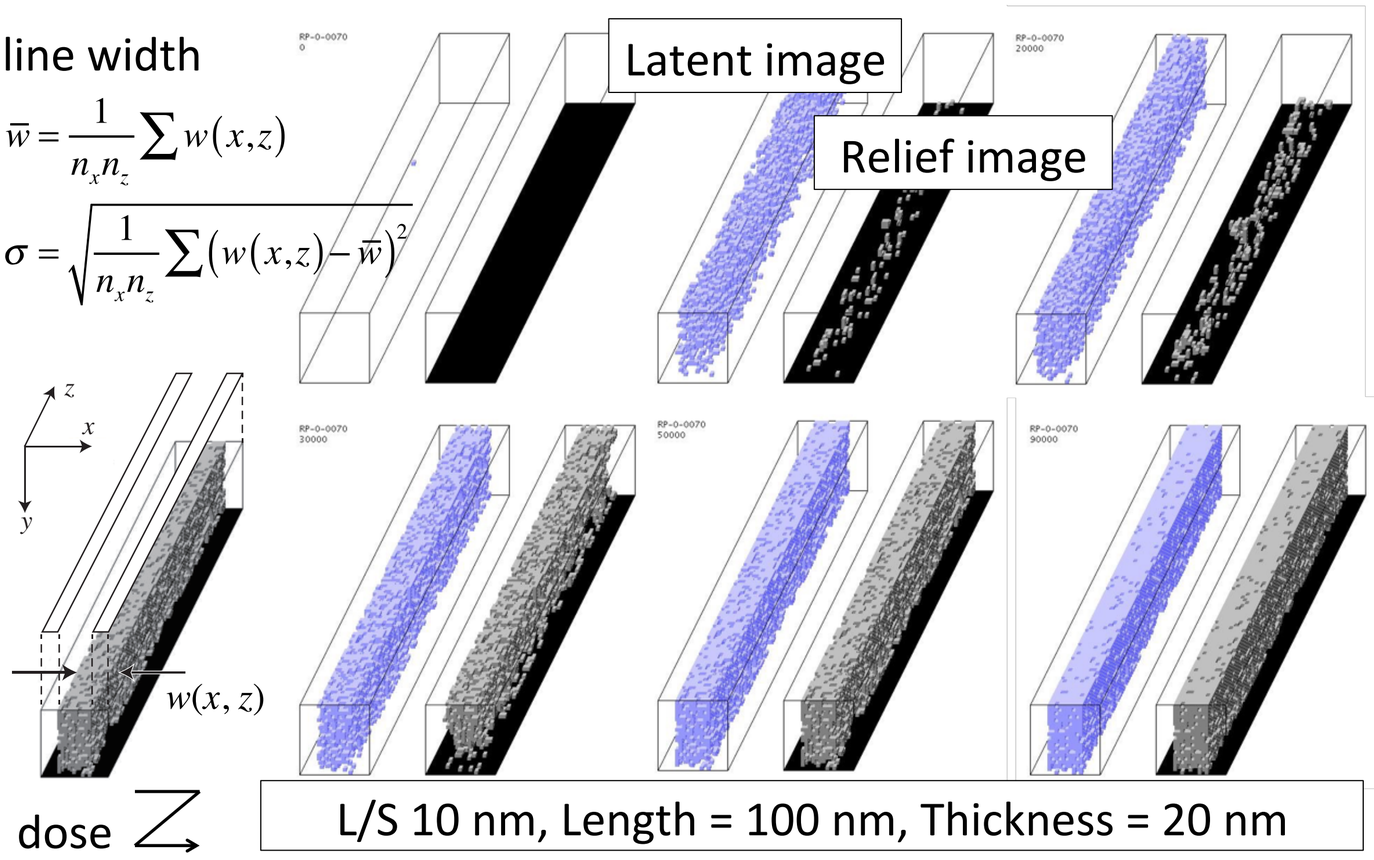
• Threshold of image formation in the negative tone resist system is investigated.

• Roughness arises from fluctuation of dose, which is specific to the EUV lithography, is investigated.

line width

$$\bar{w} = \frac{1}{n_x n_z}\sum w(x,z)$$

$$\sigma = \sqrt{\frac{1}{n_x n_z}\sum \left(w(x,z)-\bar{w}\right)^2}$$



Algorithm of calculating statistics of clusters

• A cluster consists of a head cell and subordinate cells connected consecutively beneath the head.

• Each cell has 0 or 1 parent cell and 0≤ child cell(s); each cell has references to parent and child cells.

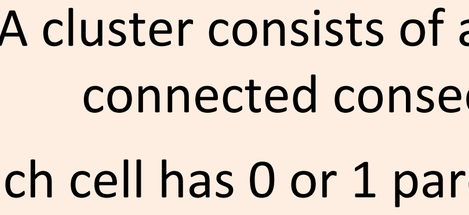
• Any configuration of clusters can be represented.

• Present method is fast and reliable for investigating statics after each event of addition of a cell.

head

Head cell represents the cluster.

Size of the cluster can be calculated recursively counting the number of child cells from the head



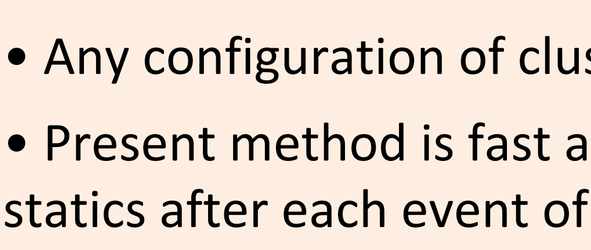
Adding a new cell

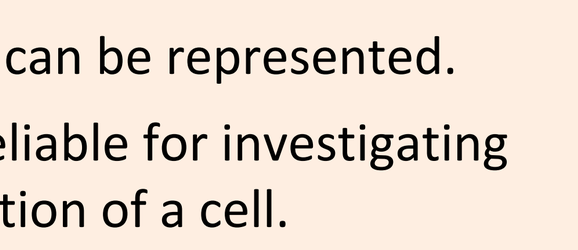
(adding a resist particle which is exposed)

Connections with existing clusters are investigated, and if so the new cell is added to the cluster.

Joining clusters

If two clusters are connected, one cluster is joined to another and connection to its head is reversed.





Model

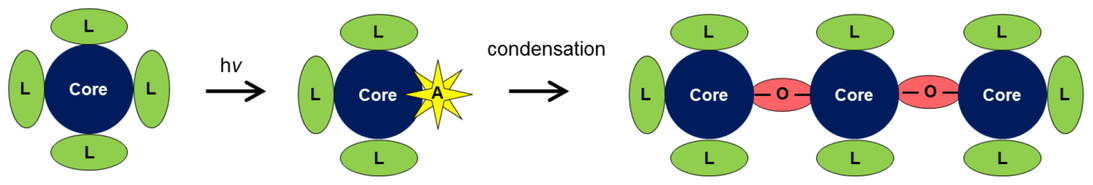


Figure 1. Two-dimensional representation of the basic elements of the MOx resist imaging model.

W. Hinsberg, Proc. SPIE 10146 (2017) 1014604

• The resist particle is assumed to be a cube with a side of 1 nm, which forms a lattice.

• The resist particle changes from solvable to insolvable state to the developer by absorbing EUV photon.

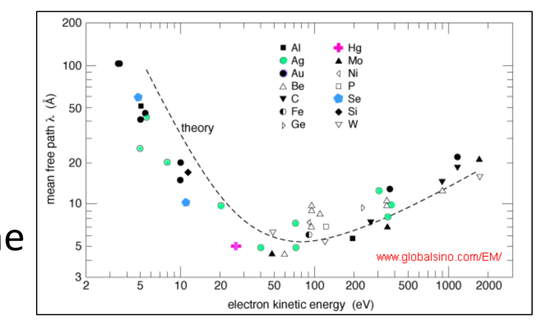
• Insolvable particles form clusters; clusters, which have connection to the substrate, form the relief image.

• EUV photon impinges normal to the film.

• The resist particle which absorbs the photon is decided randomly using the probability according to the Lambert law.

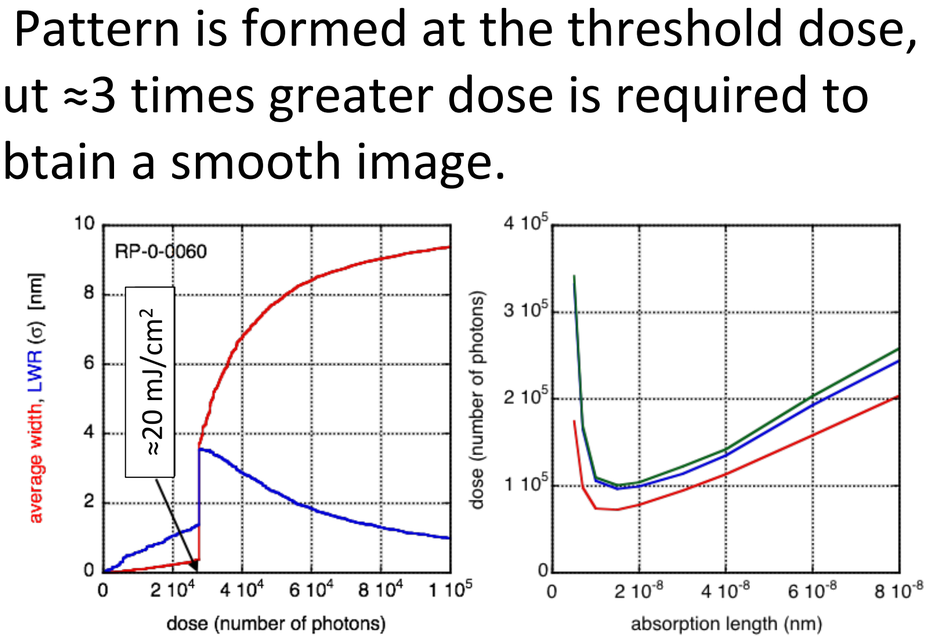
• Absorption coefficient of particle does not change by the exposure.

Exposure of EUV causes photoionization to produce secondary electrons, which have very short range (≈1 nm), should remain inside the particle to change its state.



Results

• Pattern is formed at the threshold dose, but ≈3 times greater dose is required to obtain a smooth image.



• Line width becomes narrower toward the substrate because EUV intensity decreases as it penetrates into the film.